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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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Additional inventors are being named on the one (1) *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

DESIGN OF A CERAMIC-LINED MANIFOLD WITH A METAL CLAMSHELL EXTERIOR

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS ***(check all that apply)***

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[ ] Application Data Sheet. See 37 CFR 1.76

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Fee Transmittal

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

[X] Applicant claims small entity status. See 37 CFR 1.27.

[X] A check or money order is enclosed to cover the filing fees.

[X] The Director is herby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 16-0820

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[X] No.

[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ______

[Page 1 of 2]

Respectfully submitted,

SIGNATURE

Date April 2, 2004

REGISTRATION NO. 48719

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PROVISIONAL APPLICATION COVER SHEET
Additional Page

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Docket Number 36624

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Number 1 of 1

Patent Application

Design of a Ceramic-Lined Manifold with a Metal Clamshell Exterior

This application discloses and describes additional improvements to the exhaust manifolds disclosed in Provisional Patent Application No. 60/549,793 filed March 3, 2004, and Utility Patent Application No. 10/008,828 originally filed December 7, 2001. The contents of each of these prior applications are incorporated herein by reference in their entirety.

1. It describes a technique of creating a seal between the ceramic appliance or inner layer, which is in contact with the exhaust gases, and the metal clamshell or outer layer.
2. It describes a method how the insulation between the ceramic and the metal clamshell is uniformly and accurately applied and how it is uniformly compressed to provide a consistent compression and pressure against the ceramic to metal clamshell sealing surface, and how the thickness is uniform and how it is installed in a fashion so that the insulation does not get between the clamshell mating surfaces.

Background

Provision Patent Application No. 60/549,793 teaches a technique for producing a ceramic lined exhaust manifold for an internal combustion engine that has a number of significant advantages:

1. The ceramic lined manifold has a higher temperature tolerance than cast iron manifold permitting the engine to run hotter and thus more efficiently. Operating an engine at high temperatures typically requires manifolds made of expensive specialty materials, such as stainless steel.
2. The manifold reduces the temperature inside the engine compartment, thereby reducing the need for heat resistant materials, such as silicone spark plug wires, and permits the use of less expensive thermoplastic materials.
3. It allows the catalytic converter to heat up more quickly, and in some cases, may eliminate the need for supplemental "pup" converters that are sometimes attached close to the manifold to reduce start up emissions.
4. It eliminates the need for heat shields.
5. With reduced manifold heat, there is greater design flexibility, more tightly compressing the engine and its accessories within a smaller engine compartment. The packaging can be tighter, the engine compartment smaller, and rubber and thermoplastic parts can be closer to the exhaust manifold.

Although a proven concept, the durability of the ceramic lined manifold is dependent upon a) the design of a durable ceramic to metal seal and insulation that will remain in place through many years of service.

The manifold design has one common problem that is shared with a catalytic converter, and two very different problems.

1. The major problem with designing the insulation package on both the ceramic manifold and the catalytic converter is that the metallic outer shell expands with heat more rapidly than the inner ceramic component. In both cases the insulation design can incorporate vermiculite intumescent material that expands with heat, thereby reducing the gap between the ceramic inner layer and the metal casing. With the manifold the design problem is more difficult because the ceramic inner layer has a more complex shape, it is longer, thinner, and subject to more severe thermal shock, vibrations and high velocity gases than the ceramic monolith in a catalytic converter.
2. The manifold is compressed and sealed against the cylinder head and it slides back and forth as the manifold and the head heat up and cool down at different rates and amounts. A soft sealing material, which would seal a ceramic well, would wear away with the constant sliding back and forth. The design taught in this patent allows a soft compliant seal in contact with the ceramic, yet retains the stiffer less compliant gasket to seal the manifold to the cylinder head.
3. At the exhaust end of the manifold, it is necessary that the ceramic material of the inner layer not come in contact with the mating surface of the exhaust pipe. Such contact, either during assembly or over time, could lead to a fracture of the more fragile ceramic. In addition, the seal at the cylinder head end of the manifold is cooled by the water in the water jacket of the cylinder head. The down pipe, however, has no such cooling capability, and must therefore be designed to not allow the high temperature of the exhaust to affect the metal casing or outer layer if it is made of aluminum.

Exhibit 1 shows a cutaway of a clamshell manifold made by a technique taught in this application.

Affecting a Cylinder Head to Manifold Seal

Exhibit 2 shows the drawing of a typical manifold seal to the cylinder head. It shows the exhaust port seal detail including a) the exfoliated (EF) graphite/fiber seal sealing the metal case of the manifold against the slip formed (SF) ceramic internal structure, b) the traditional exhaust manifold gasket system that seals the clamshell aluminum manifold against the cylinder head, and c) the inconel shield that protects the EF/fiber seal from direct impingement of exhaust gases. This seal is best incorporated with exhaust manifold-to-cylinder-head gasket system. Exhibit 2d shows the cylinder head attached. Exhibit 2d shows a cross section of the ceramic component in the manifold. Exhibit 2 shows the seal partially compressed, sealing the ceramic liner and the inside of the clamshell surface. A proper seal requires that the EFG/fiber gasket be placed into the lower half of the clamshell matching the exhaust ports that lead into the cylinder head. The insulation (f on Exhibit 2) has the purpose of pushing the ceramic inner layer tightly against the EFG gasket in such a fashion so that there is a consistent compression and the proper amount of pressure to hold this amount of compression. A key feature of this invention is to provide one sealing surface between the ceramic inner layer and the manifold metallic shell and the other between the manifold metallic shell and the engine head. As a result, the sealing of the manifold's inner ceramic layer is not affected when the manifold is bolted to the cylinder head. The seal integrity (between the ceramic layer and the metallic shell) can be tested during the

manufacturing process of the manifold itself and it is not left to the final engine assembly operation.

The seal compositions:

1. The base material can be either carbon such as Grafoil or oxidation resistant ceramic such as alumino-silicate fiber.
2. If the seal material is a carbon-based composition, it is fabricated with additives to render it oxidation resistant. For example, the Grafoil may be impregnated with borate or phosphate glass of a metallic element such as zinc and ceramic fillers such as TiB2, SiB6, TiC.

   On the other hand, if the sealing material is made out of ceramic fiber, then it is necessary to select fiber compositions that will not undergo slow shrinkage or fracture during operating conditions. It will be necessary to compress such a seal so that under any operating conditions, the movement between the two surfaces will exhibit totally elastic deformation.

   It is also possible to construct a seal that has two parts; the one facing the hot exhaust is made out of ceramic fibers while the one in the interior is made of a carbon based composition. An advantage of such a design would be combined oxidation resistance of ceramic fibers and excellent sealing capability of graphite based materials like Grafoil.

3. To the base composition for the seal material, thermally conductivity enhancing additives may be included. The result of such additives would be to make the seal more thermal conductive. As a result, its temperature can be kept sufficiently low to prevent its oxidation.

CLAIMS

In a manifold for an internal combustion engine made with a slip cast or slip formed (SF) ceramic inner layer (which conveys the exhaust gas) with a metal clamshell exterior containing the ceramic inner layer, we claim the following intellectual property:

1. The metal clamshell seal to the SF ceramic inner layer by the exhaust ports in the area where the manifold is fastened to the cylinder head where the seal gasket is positioned inside the clamshell (see Exhibit 2), instead of against the cylinder head. The ceramic inner layer is completely encased within the metal clamshell, and does not come into contact with the cylinder head. This design has three advantages:

   a. Since the ceramic is inside the manifold and is not exposed, it protects the ceramic from damage during handling and while it is being assembled to the engine.

b. It permits more precise compression of the SF ceramic into the gasket. The precise percentage compression of the sealing gasket is made easier.
c. It allows for the use of a softer gasket being in contact with the SF ceramic. If the ceramic was sealing directly against the head, a soft gasket would wear as the manifold slid back and forth over the surface of the cylinder head. In a conventional manifold to cylinder head surface seal, the gasket is extremely hard and compresses only a slight amount, perhaps 10-15%. The gasket seal for the SF ceramic will compress over 30%.

2. The SF ceramic seal to the clamshell of an exfoliated graphite (EFG) material with the trademark of Grafoil produced by Union Carbide in Lakewood, Ohio, except with less than half the amount of compaction that is customary with an EFG gasket. The EFG gasket will provide less stress on the SF ceramic. The gasket is made so the seal compresses directly against the inside surface of the metal clamshell. As the SF ceramic is pushed into the gasket, the gasket will push upward and crush against the exterior surface of the SF ceramic. This is shown in Exhibit 2. Grafoil seal can be impregnated with additives to make it more oxidation resistant. In addition, additives to increase thermal conductivity may be included in the composition. The seals can be either a) all graphitic or Grafoil based, b) all ceramic fiber based or c) combinations of a) and b).

3. Centerline of the exhaust ports on the SF ceramic has approximately a 90° angle with the inside surface of the clamshell. This has the effect of more effectively compressing the gasket against the exterior (radial) surface of the SF ceramic. This leads to a more positive seal and better durability.

4. A retention ring can be molded into the metal clamshell at the top surface of the gasket. This ring has a small enough interior dimension, so that it does not touch the SF ceramic causing a possible failure. However, as the gasket is compressed the ring forces the EFG gasket against the outer radial surface of the SF ceramic. See Exhibit 3 for a diagram showing with the ring in place.

5. A high temperature metal, preferably stainless steel or inconel preferably .006"-.015" thick projects from the surface of the gasket that seals the clamshell manifold to the cylinder head down into the interior of the slip formed ceramic. The purpose of this metal stamping is to protect the surface of the EFG gasket from the turbulence of the exhaust gases putting the EFG gasket in "still" air. Exhibit 2 shows a detail of this baffle construction. It is possible and preferred that this high temperature metal material is built into the manifold gasket (the gasket sealing the manifold to the cylinder head – <u>not</u> the gasket sealing the slip formed ceramic to the clamshell).

6. Design of the slip formed ceramic is fashioned as shown in Exhibit 4, so that the main channel, into which the exhaust ports connect, is as close to being round as design permits, and the exhaust ports that intersect to it, intersect at the same diameter as the main tube, and cone down to fit the exhaust port. Ideally, the exhaust ports are round, permitting the greatest volume of exhaust flow per unit of surface area, and also

allowing for the slip formed ceramic to be round at its "upstream" end to permit the greatest amount of force against the EFG gasket. TA round surface will allow greater compression of the insulation material and will permit the SF ceramic to be held more tightly against the EFG/fiber seal.

7. The insulation is applied in three different ways. As Exhibit 5 shows, the slip formed ceramic is wrapped with insulation in the five locations designated, 1, 2, 3, 4, and 5. These strips allow for a more uniform thickness than would be possible with vacuum deposited or compression molded ceramic fiber. This is wrapped around the slip formed ceramic, and where the two ends come together, it is a saw-tooth cut to minimize the ability for gas to travel through where the strips are butted together. On sections 6, 7, and 8, these are half-formed pieces that are held in place with a contact adhesive or low volatility glue that can burn off quickly during a seal test or when the engine is tested. Insulation items no. 9, 10, 11, 12, 13, 14, and 15 can be formed by compression molding the insulation matrix, which is made up of fibers and ceramics by either vacuum forming, compression molding, or die cutting depending on the specific design in question. Voids should be minimized, but if there are void areas that appear, a technique of pumping liquid slurry into the void areas can be employed. The volatile component of the liquid can be water, but is preferable to be alcohol or another liquid carrying agent that has high volatility and will flash off quickly.

In order to facilitate the installation of the gasket materials other than insulation materials, during assembly a metal shim stock material is laid into the bottom clamshell outside of the insulation, but inside of the metal clamshell. The parts are then pushed together sliding the shim stock inside the clamshell as it compresses from the top. In this manner, the insulation does not get into the seal area between the two clamshells' mating surfaces, which allows for a tight debris-free seal between the two clamshells.

To retain the clamshells in place, they can be either held together by auxiliary fasteners that hold the clamshells together prior to the installation of the manifold on the engine, or the two clamshells can be welded together, e.g., using an automatic welding device.

8. The preferred method of assembly is to place the bottom clamshell section exhaust ports down on a table as is shown in Exhibit 6. The slip formed ceramic is pressed into the bottom clamshell section, which compresses the insulation and the EFG. The fixture shown defines the force to compress at a specific compression of the EFG. These values are preferably taken at four points on the manifold, preferably at least in the areas shown on Exhibit 6. These locating points show that above ports no. 1 and no. 4 the force is even on all four-load cells placed at each of the four locating points. If it is not equal, adjustments must be made to the insulation to make them equal. The exact amount of pressure depends upon the type of ceramic insulation used. Too much force or a high variability of forces at the four different load cells could cause the slip formed ceramic to crack. Too little force could cause it to come loose and

rattle later, or it could cause the release of compression on the EFG gasket, either of which could lead to the failure of the manifold.

9. Manifold to down pipe seal and design detail. Exhibit 7 shows the design of the down pipe seal and other design detail.

   a. A steel ring that fits snugly against a recess in the clamshells and which acts to hold the clamshells together. The steel ring can be fastened in place with a small fastener in the back. This eliminates the possibility that it is put in improperly and could crack the SF ceramic interior. There is an angle on the inside of the steel ring that acts to compress the EFG/fiber gasket radially against the SF ceramic. There is small clearance between the steel ring and the ceramics. This space can be filled, bridged (partly) with stainless steel shims that can slightly compress. The purpose of the small clearance and the steel shims is to keep the gasket from oxidizing in this high temperature environment when exposed to too much oxygen.
   b. A gasket-retaining ring built into both of the clamshell sections that retain the gasket against the SF ceramic but do not touch the ceramic.
   c. The steel ring is tapered to accept a traditional down pipe gasket, a common type of which is a compression molded stainless steel gasket filled with graphite.

10. An SF ceramic inner layer that is made out of two or more segments, as opposed to the unitary inner layer described above. The segmented layer absorbs the differential in thermal expansion between the metallic shell and the SF ceramic. Exhibits 8 and 9 describe 2 embodiments of this structure.

11. Method for sealing ceramic core or inner layer to a metal outer layer or clamshell, preferably an aluminum shell.

   a. In this high temperature application (internal gases 1850°F), the ceramic inner layer may be sealed to the outer shell using molten aluminum. The molten aluminum will enter the voids and cracks between the ceramic inner layer and the outer shell in the port area. A practical technique of filling the voids is by dipping the ceramic inner layer, shell assembly into molten aluminum in the area to be sealed. The assembly (manifold) to be sealed will be held with ports down and carefully inserted into molten aluminum (1/4 to 1/2 inch in depth, preferably) and then removed. A brief pause in the air will solidify the aluminum. The process may be repeated until all cracks and voids are sealed.

   b. Excess molten or sealing metal (aluminum) may be removed by mechanical methods.

   c. Prior to dipping, coatings can be used to aid in metal adhesion where wanted, and to prevent metal adhesion where not wanted.

Exhibit #1

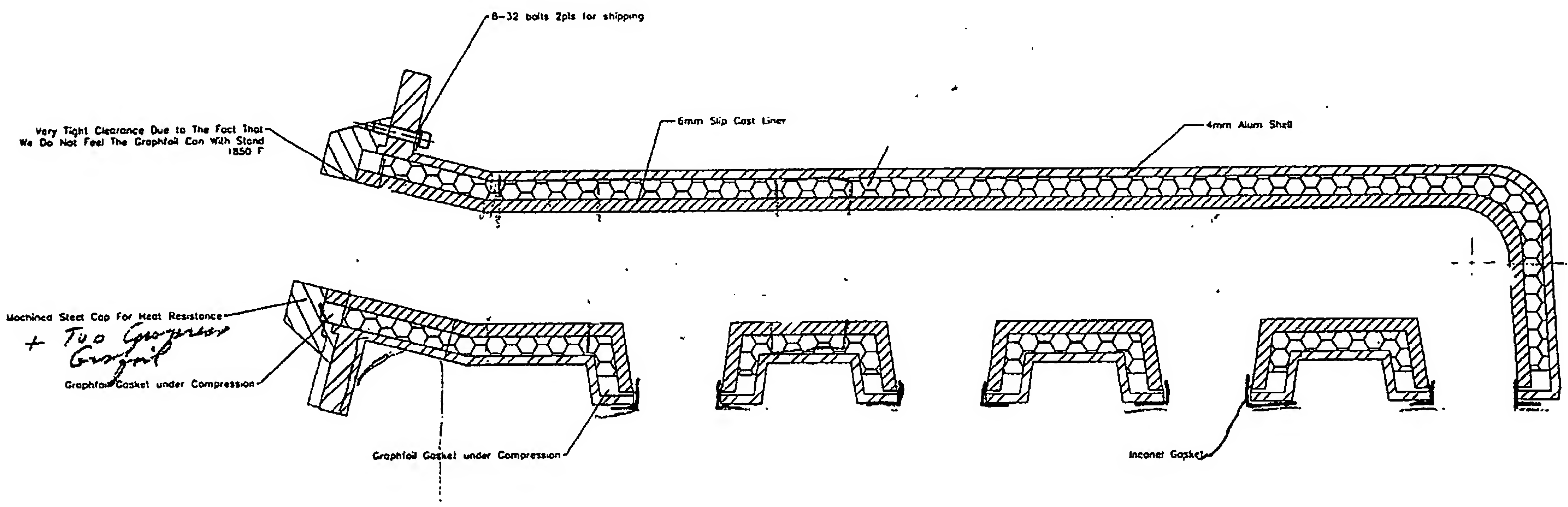

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Exhibit #2

Exhaust Port Design Detail

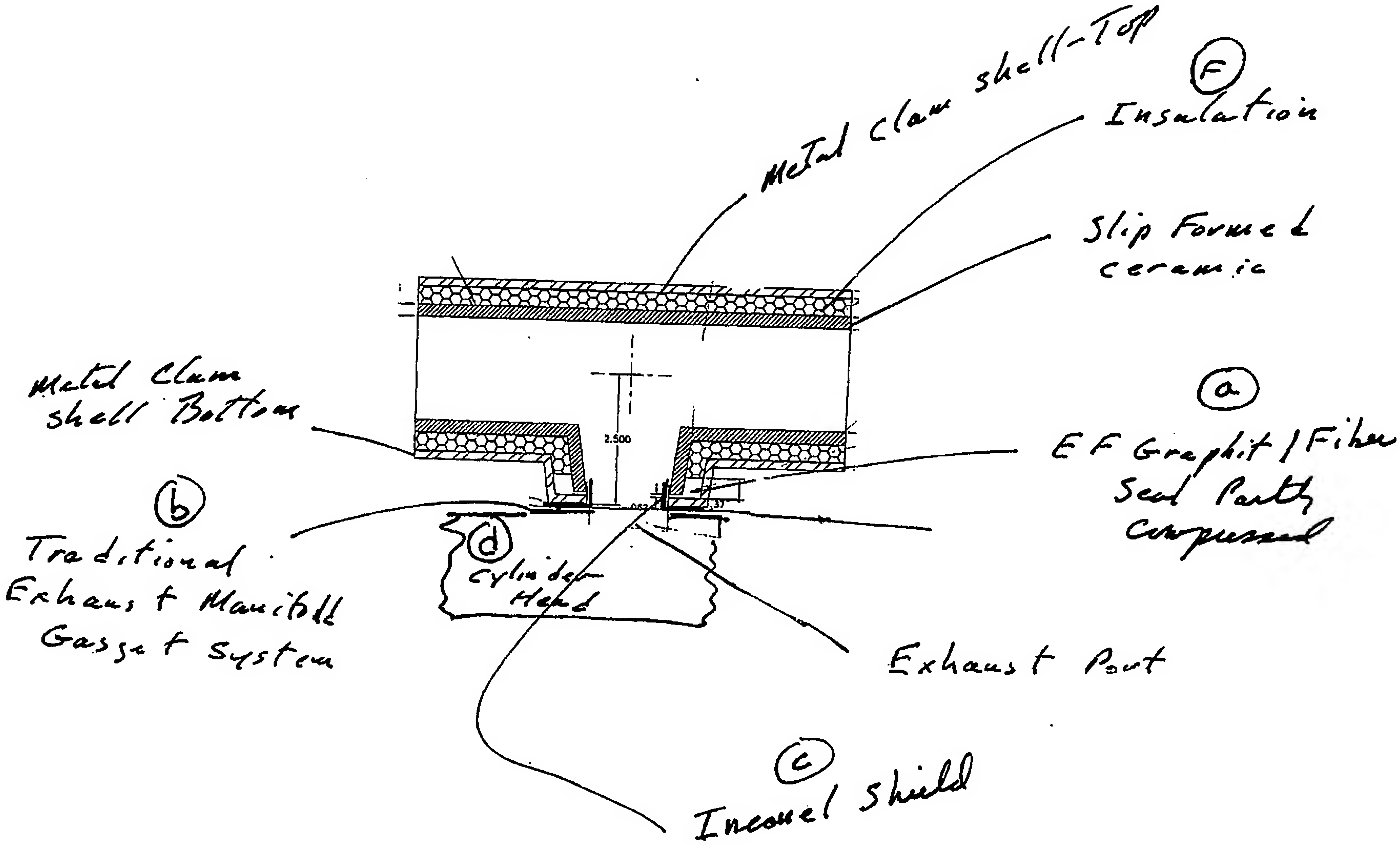

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Exhibit #3

Diagram of Port in Clam Shell Ceramic Manifold With Retention Ring in Place

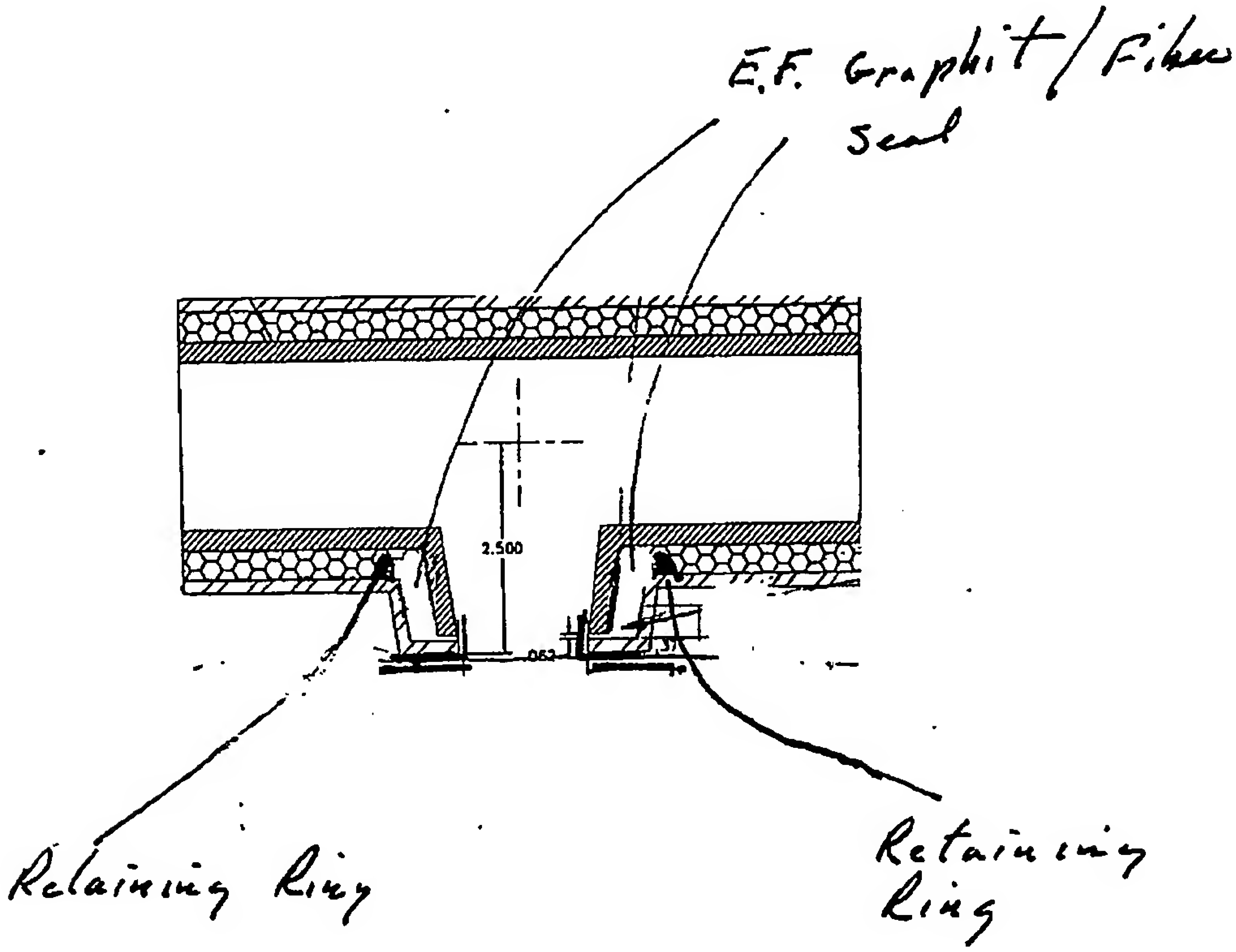

Exhibit #4

Prefered Design
of Slip Cast Ceramic
Component of Clam Shell
Ceramic Exhaust Manifold

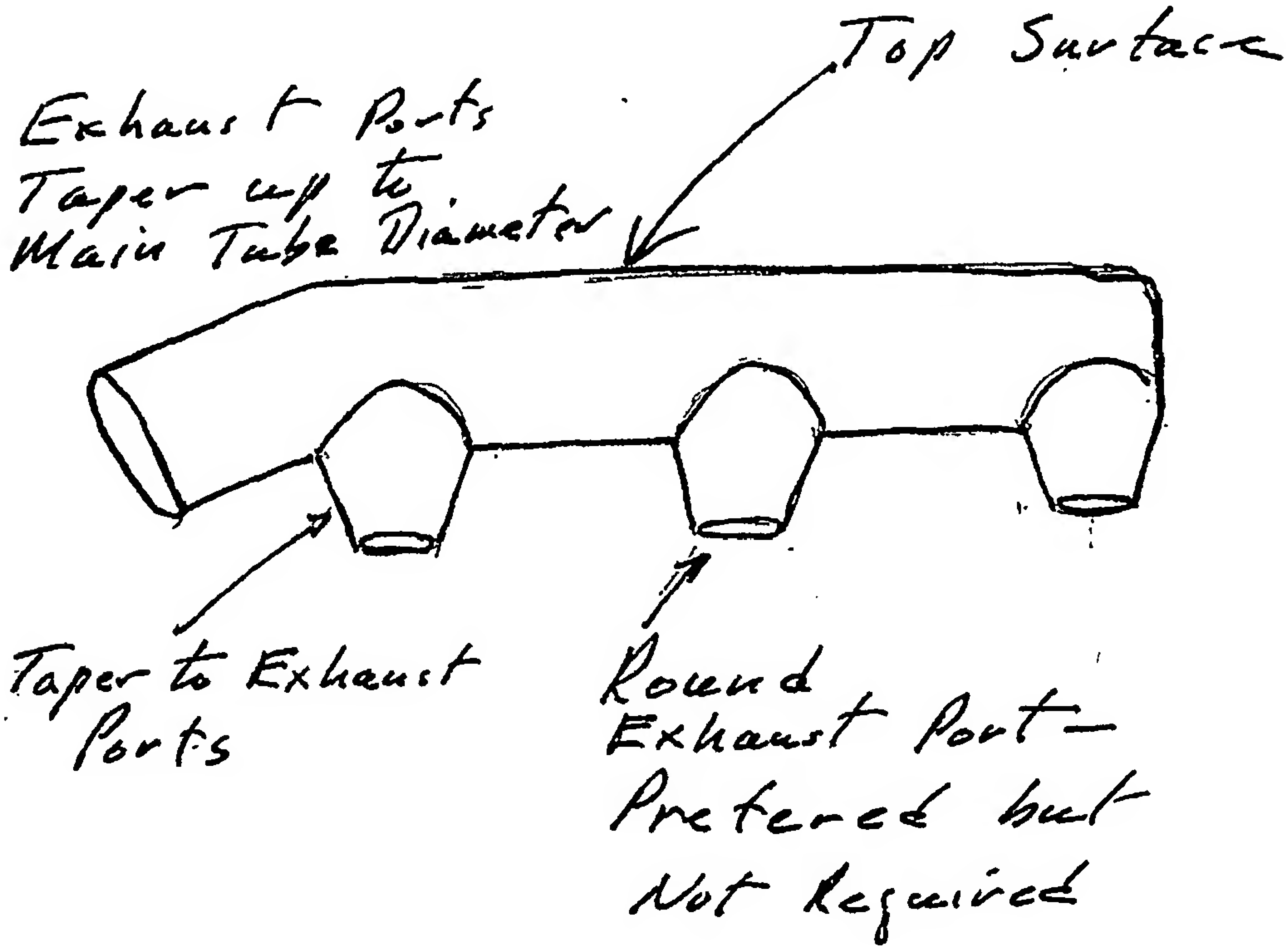

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Exhibit #5
Placement of Insulation
Materials

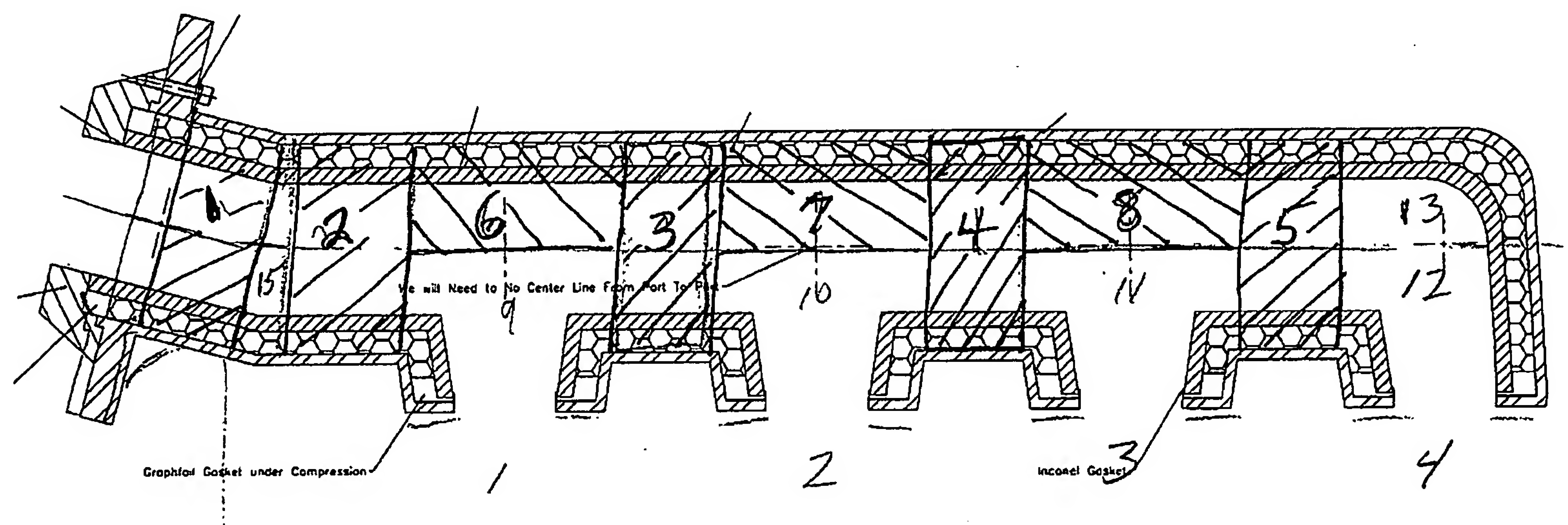
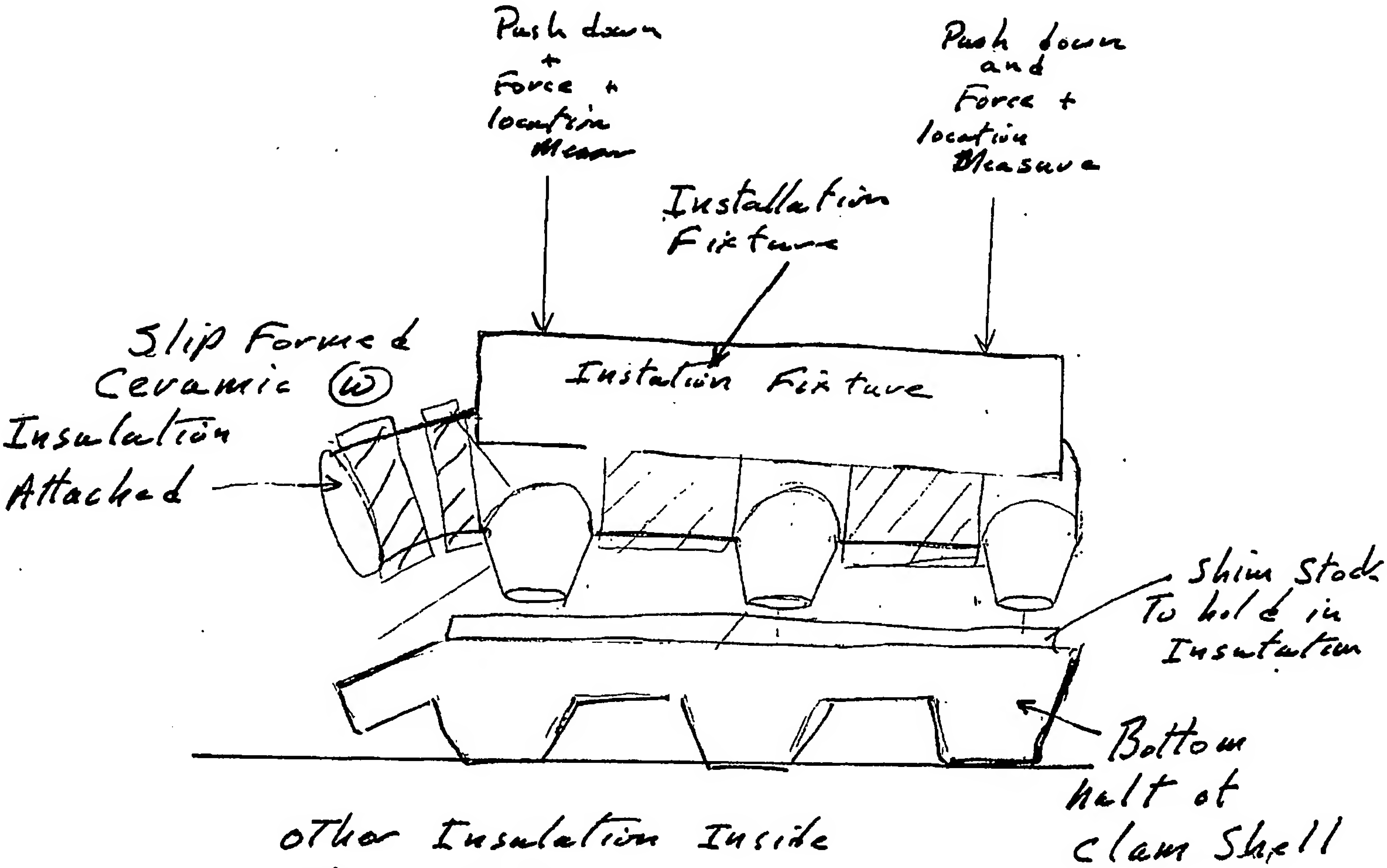


Exhibit #6

Assembly Diagram
Slip Formed Ceramic to
Bottom 1/2 of Clam Shell Manifold



other Insulation Inside
clam shell

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Exhibit #7
Manifold to Down Pipe Seal
and Design Detail

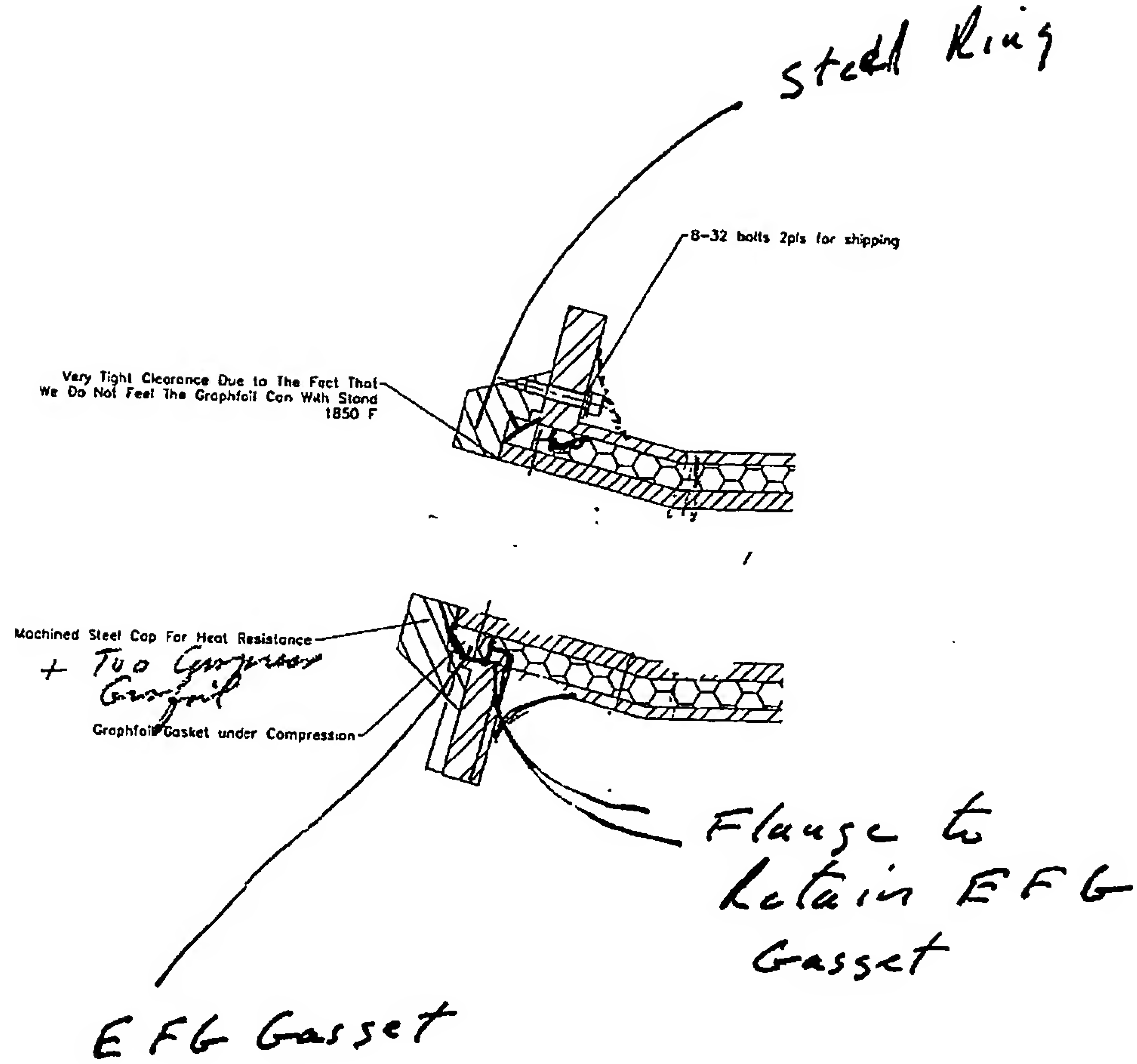

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EXHIBIT 8

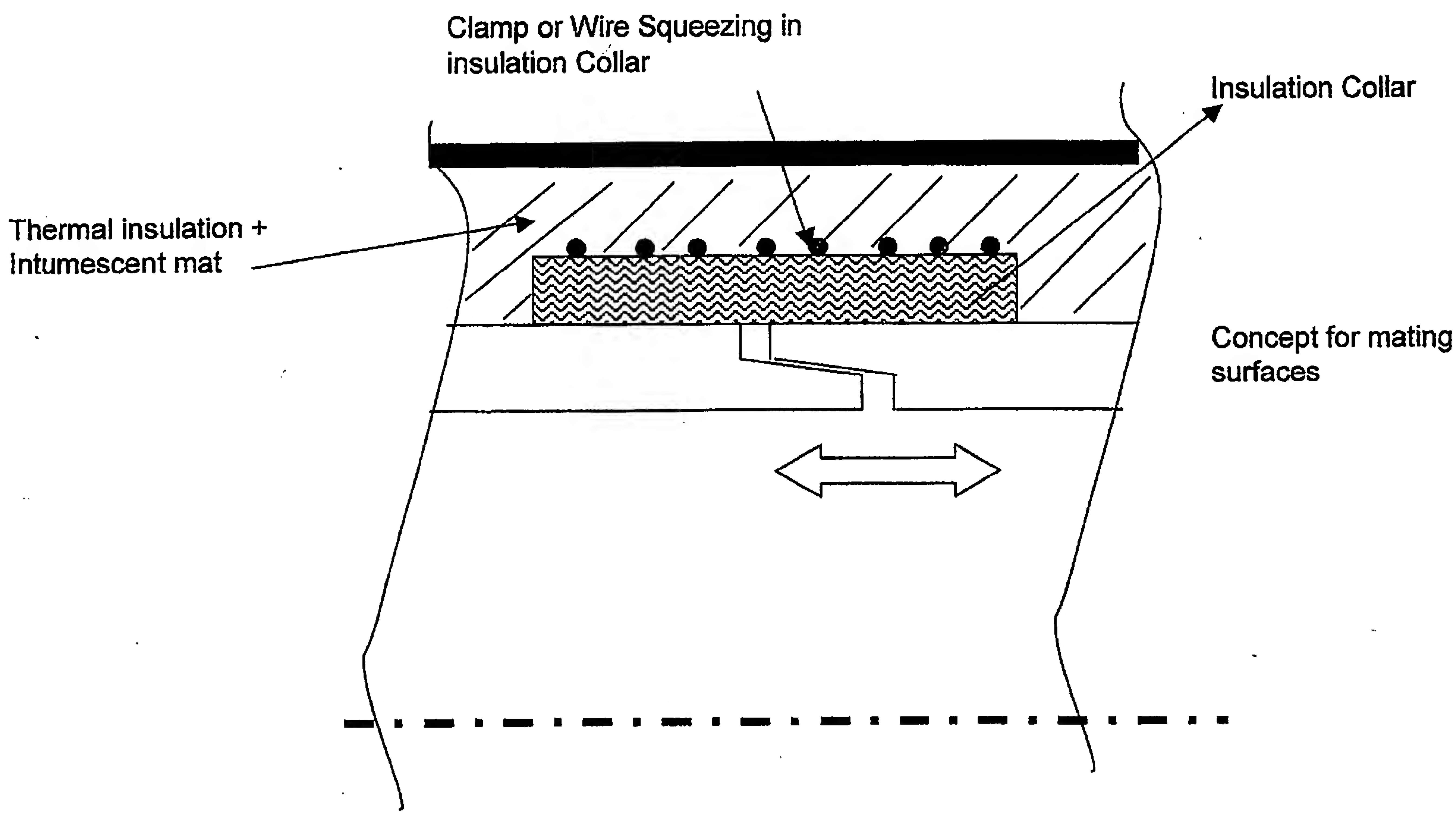
Clamp or Wire Squeezing in insulation Collar
Insulation Collar
Thermal insulation + Intumescent mat
Concept for mating surfaces

EXHIBIT 9